



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION VII
901 NORTH 5TH STREET
KANSAS CITY, KANSAS 66101

JUN 20 2003

MEMORANDUM

SUBJECT: Preliminary Remediation Goals for Lead
Herculaneum Lead Smelter Site
Herculaneum, Missouri

FROM:

Mike Beringer
Toxicologist
ENSV/DISO

A handwritten signature in black ink, appearing to read "Mike B", is written over the typed name "Mike Beringer".

TO:

Bruce Morrison
Remedial Project Manager
SUPR/FFSE

As you requested, I have developed preliminary remediation goals (PRGs) for surface soil based on exposure of residents to lead for the Herculanum Lead Smelter Site. Soil PRGs were calculated for children 0 to 84 months of age using the Integrated Exposure Uptake Biokinetic (IEUBK) Model with site-specific bioavailability and airborne emissions data. The supporting documentation and results are attached. If you have any questions, please let me know.

Attachment

40338487



Superfund

Preliminary Remediation Goals for the Herculaneum Lead Smelter Site Herculaneum, Missouri

1.0 Site Description and History

The lead smelter currently operating in Herculaneum, Missouri, is owned and operated by the Doe Run Resources Corporation (Doe Run). This lead smelter facility has been operating for over 100 years and consists of two main areas, the smelter plant and the slag pile. It is bordered on the east by the Mississippi River, on the west and north-northwest by residential areas, and on the south-southwest by the slag pile. Several hundred individuals reside within one-half mile of the facility, with over two thousand people residing within two miles of the facility. There are also several homes within 200 feet of the smelter and the slag pile.

As part of its operations, lead is emitted from the Herculaneum smelter into the ambient air and ultimately is deposited onto the surrounding surface soil. The facility has not historically been able to control the amount of lead emitted into the ambient air so as to attain the National Ambient Air Quality Standard (NAAQS) for lead. Several environmental investigations have documented the presence of elevated lead concentrations in surface soil in Herculaneum. In addition, elevated blood lead levels have been documented in children who live near the facility. As a result, Doe Run is excavating and replacing surface soil in residential yards, parks, playgrounds, and schools in the community, as well as cleaning home interiors to reduce dust levels.

2.0 Purpose and Scope of This Document

This document provides preliminary remediation goals (PRGs) for lead in surface soils in residential areas of Herculaneum, Missouri. It is important to note that a preliminary remediation goal is not a final cleanup goal, which is dependent upon additional risk management considerations such as costs of remedial options, reliability of institutional controls, technical feasibility, and/or community acceptance. The methods used to derive residential soil PRGs for lead are consistent with current EPA guidance on development of preliminary remediation goals (EPA, 1991), as well as policies and guidance on lead risk assessment (EPA, 1994a, 1998).

3.0 Derivation of Residential Soil PRGs for Lead

3.1 Overview

Risks from lead are evaluated using a somewhat different approach than for most other metals. First, because lead is widespread in the environment, exposure can occur by many different pathways. Thus, lead risks are usually based on consideration of total exposure (all pathways) rather than just to site-related exposures. Second, because studies of lead exposures and resultant health effects in humans have traditionally been described in terms of blood lead

(PbB) level, lead exposures and risks are typically assessed using an uptake-biokinetic model rather than calculating an estimated dose and comparing that dose to an appropriate reference dose (RfD). Therefore, calculating the level of exposure and risk from lead in soil also requires assumptions about the level of lead in other media, and also requires use of pharmacokinetic parameters and assumptions that are not needed in traditional risk assessment methods.

For residential land use, the subpopulation of concern is young children. This is because young children (1) tend to have higher exposures to lead in soil, dust, and paint; (2) tend to have a higher absorption fraction for ingested lead; and (3) are more sensitive to the toxic effects of lead than are older children or adults.

3.2 Current Guidelines for Protecting Children from Lead

EPA's Office of Solid Waste and Emergency Response (OSWER) has established a health protection goal of limiting exposure to soil lead levels such that a full-time child resident would have no more than a 5% chance of having a blood lead value above 10 µg/dL (EPA 1994a, 1998). This approach focuses on the risks to a child at the upper bound (about the 95th percentile) of the exposure distribution, very much the same way that the approach used for other chemicals focuses on the Reasonable Maximum Exposure scenario. The basis for this goal is that adverse health effects associated with childhood lead exposure have been determined to occur at a blood lead concentration of 10 µg/dL (EPA, 1986, 1990; CDC, 1991).

3.3 IEUBK Model for Assessing Lead Risk

EPA has established a national policy of using the Integrated Exposure Uptake Biokinetic (IEUBK) Model for Lead in Children as the primary tool for setting risk-based soil cleanup levels at lead sites for current or future residential land use (EPA, 1994a, 1998). The IEUBK model is a computer-based deterministic simulation that predicts the plausible range of blood lead levels in a hypothetical child or population of young children (0 to 84 months) exposed to environmental sources of lead (EPA, 1994b, 1994c). This model requires as input, data on the levels of lead in soil, dust, water, air and diet at a particular location, and on the amount of these media ingested or inhaled by a child living at that location. The inputs to the IEUBK model are selected to reflect central tendency values (i.e., arithmetic means or medians). These estimated inputs are used to calculate an estimate of the central tendency (the geometric mean) of the distribution of blood lead values that might occur in a hypothetical child or population of children exposed to the specified conditions. Assuming the distribution is lognormal, and given (as input) an estimate of the variability between different children (this is specified by the geometric standard deviation or GSD), the model calculates the expected distribution of blood lead levels, and estimates the probability that any random child might have a blood lead value over 10 µg/dL.

EPA has also recommended 400 mg/kg as the screening level for lead in soil intended for residential land use (EPA, 1994a). Soil lead levels above 400 mg/kg may or may not be of concern, depending on site-specific factors, but do warrant additional site-specific study of the

risks. The residential screening level for lead is based on using the IEUBK model with default input parameters.

3.4 Site-Specific Data

Whenever reliable site-specific data are available on any of the IEUBK model input parameters, these data are used in preference to the recommended default assumptions. Site-specific bioavailability and airborne emissions data for lead are available for the Herculaneum lead smelter.

Bioavailability Data

The Doe Run Company performed a study to investigate the relative bioavailability of lead in residential yard soils (Doe Run, 2001). A single composite of 12 soil samples was fed to young swine for 15 days to measure the gastrointestinal absorption of lead. The soil samples were collected in the first 1 inch of topsoil at residences in Herculaneum. Young swine were selected as the test species because it is believed the gastrointestinal system (and hence the behavior of ingested lead) in swine is similar to that of young children. EPA has recommended use of this animal model for determining the site-specific bioavailability of lead (EPA, 1991). The details of the study design and of the findings are presented in a separate report (Doe Run, 2001). The study found that lead in site soils was absorbed by swine about 71% as well as a readily soluble form of lead (lead acetate). In other words, the relative bioavailability (RBA) of lead in soil was 71%. Based on a default absorption fraction of 50% for lead in water and food, this RBA corresponds to an absolute bioavailability of 36% (0.36) which is the input parameter used in the IEUBK model.

This RBA value is somewhat higher than the recommended default value of 60%, suggesting that the lead in site soils is in a form that can be readily absorbed by children. An RBA of 71% is within the range of values obtained from other lead smelter sites and it is appropriate for use in deriving a preliminary remediation goal for this site. However, there is uncertainty with using this value because only a single composite of soil samples in Herculaneum was evaluated and physical-chemical data on the soil samples were not provided in the study report.

Airborne Emissions Data

The Missouri Department of Natural Resources (MDNR) is currently collecting lead ambient air data at seven monitors located in the vicinity of the Doe Run Herculaneum lead smelter. Data from Dunklin #1, Dunklin #2, Bluff, Sherman, and the Broad Street monitors were used to estimate airborne levels of lead in Herculaneum because these monitors are all located within a one mile radius of the facility. Monitoring results from the most recent four quarters beginning in April 2002 through March 2003 were used in this assessment. The Dunklin #1 and #2 results were first averaged and treated as one result because the monitors are co-located at the

Dunklin High School. A community-wide airborne lead concentration of $0.60 \mu\text{g}/\text{m}^3$ was obtained by calculating the arithmetic average of the Dunklin, Bluff, Sherman, and Broad Street monitor locations.

It is also appropriate to consider the Broad Street results separately because several residences are adjacent to the lead smelter facility. The arithmetic average lead concentration at this location is $1.43 \mu\text{g}/\text{m}^3$, which is nearly equal to the NAAQS of $1.5 \mu\text{g}/\text{m}^3$. Both the community-wide and Broad Street air concentrations are significantly greater than the IEUBK model default of $0.1 \mu\text{g}/\text{m}^3$.

3.6 Calculation of Residential Soil PRGs for Children

To derive soil lead PRGs for children (0 to 84 months) in a residential setting, all IEUBK model input parameters were set to the defaults recommended by EPA except for the soil/dust bioavailability and outdoor air lead concentration (see Tables 1 and 2). Separate PRGs were calculated for the community-wide outdoor lead concentration and based on the Broad Street monitoring results. It is important to note that this assessment assumes no additional contribution of lead from local dietary sources, such as fruits, vegetables, meat, and fish, because site-specific data are not available.

Multiple runs were conducted for a range of soil concentrations using the Windows version 1.0 (build 244) of the IEUBK model to determine the soil lead concentration which equals a 5% probability of not exceeding a $10 \mu\text{g}/\text{dL}$ PbB level (EPA, 2001a, 2001b). The results indicate that a surface soil concentration of $250 \text{ mg}/\text{kg}$ will achieve EPA's health protection goal for children 0 to 84 months of age, assuming an outdoor lead concentration of $0.60 \mu\text{g}/\text{m}^3$. If one assumes that the outdoor lead concentration is $1.43 \mu\text{g}/\text{m}^3$ (i.e., Broad Street monitor), then a surface soil concentration no greater than $179 \text{ mg}/\text{kg}$ is necessary to achieve EPA's health protection goal. The surface soil PRGs for lead are substantially lower than EPA's default residential screening level because the site-specific RBA and outdoor air lead concentration are higher than the model default value for these parameters.

4.0 Uncertainties

It is important to stress that lead risk predictions based on the IEUBK model are uncertain. A significant source of uncertainty in the IEUBK model is the actual level of lead exposure that children receive from various environmental sources, which is due to uncertainty regarding environmental concentrations and children's intake parameters. For example, exposure to soil and dust is difficult to quantify because human intake of these media is likely to be highly variable, and it is difficult to derive accurate measurements of actual intake rates. Likewise, site-specific data on exposure to lead through the diet are generally not available, and because dietary lead levels have been decreasing over time, the default data used in the model may no longer be accurate. It is also difficult to obtain reliable estimates of key pharmacokinetic parameters in humans (e.g., absorption fraction, distribution and clearance rates, etc.), since

Table 1. IEUBK Model Inputs - Constants

Parameter	Value
Outdoor air concentration ($\mu\text{g}/\text{m}^3$)	0.60 and 1.43
Indoor air concentration	30% of outdoors
Drinking water concentration ($\mu\text{g}/\text{L}$)	4.0
Absorption Fractions: Air Diet Water Soil/Dust (site-specific data)	32% 50% 50% 38%
Fraction soil	45%
Fraction dust	55%
Ratio of dust lead concentration to soil lead concentration	0.70
GSD	1.6

Table 2. IEUBK Model Inputs - Age Dependent

Age	AIR		DIET	WATER	SOIL
	Time Outdoors (hrs)	Ventilation Rate (m^3/day)	Dietary intake ($\mu\text{g}/\text{day}$)	Intake (L/day)	Intake (L/day)
0-1	1.0	2.0	5.53	0.20	85
1-2	2.0	3.0	5.78	0.50	135
2-3	3.0	5.0	6.49	0.52	135
3-4	4.0	5.0	6.24	0.53	135
4-5	4.0	5.0	6.01	0.55	100
5-6	4.0	7.0	6.34	0.58	90
6-7	4.0	7.0	7.00	0.59	85

direct observations in humans are limited. Finally, the absorption, distribution, and clearance of lead in the human body is an extremely complicated process, and any mathematical model intended to simulate the actual processes is likely to be an oversimplification of what is actually occurring in children exposed to lead.

As mentioned above, this assessment assumes that there is no additional contribution of lead from local dietary sources, such as fruits, vegetables, meat, and fish because site-specific data are currently not available. Data from other sites impacted by lead mining have shown that exposure by this pathway is likely not as large as from soil ingestion, but the contribution is also not completely negligible. Therefore, omission of this exposure pathway leads to some degree of underestimation of the total risk and possible overestimation of the soil PRG.

Another important source of uncertainty in deriving a residential soil PRG for lead is the degree of absorption (i.e., bioavailability) within the gastrointestinal tract. A site-specific relative bioavailability estimate of 71% was used in deriving a residential soil PRG for lead, which equates to an absolute bioavailability of 36%. This RBA estimate is based on a single composite of soil samples from residential properties in the vicinity of the Herculanum lead smelter, while bioavailability will likely vary across residential properties containing lead. In addition, there are limited physical-chemical information on the soil samples used in the swine assay which make it difficult to evaluate the results. Further physical-chemical characterization of the soil samples collected from Herculanum would greatly enhance the interpretation of the RBA estimate, including information on the chemical form or species of lead, particle size of the metal form, and lability of the metal form.

There is also uncertainty regarding the airborne concentrations of lead because these levels will vary over time as well as across the community. The outdoor air concentrations were slightly underestimated because samples that did not exceed the laboratory method detection limit were reported as zeros, which were used to calculate the average concentration. The standard risk assessment practice is to assume that a contaminant is present at one-half the sample quantitation limit when calculating exposure point concentrations.

5.0 Summary

The IEUBK model, Windows version 1.0 (build 244), was used to derive soil lead preliminary remediation goals for residences in Herculanum, Missouri. Assuming a relative bioavailability of 71% and an outdoor air concentration of $0.60 \mu\text{g}/\text{m}^3$, a soil concentration of 250 mg/kg will achieve EPA's health protection goal for children 0 to 84 months of age. If one assumes an outdoor air concentration of $1.43 \mu\text{g}/\text{m}^3$, then a soil concentration of 179 mg/kg will meet EPA's health protection goal.

6.0 References

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